

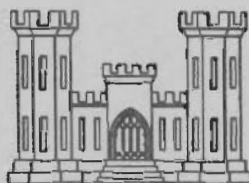
DEPARTMENT OF THE ARMY

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New England Division  
Corps of Engineers, U.S. Army  
CORPS OF ENGINEERS

BEACH EROSION BOARD  
OFFICE OF THE CHIEF OF ENGINEERS

# BEHAVIOR OF BEACH FILL AT OCEAN CITY, NEW JERSEY

TECHNICAL MEMORANDUM NO. 77



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CORPS OF ENGINEERS

FEBRUARY 1956

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## FOREWORD

This report presents the results of a study of movement of beach material made in connection with a beach fill operation at Ocean City, New Jersey. The beach fill was placed by the State of New Jersey in cooperation with the city of Ocean City generally in accordance with a plan developed by the Corps of Engineers. In addition to its mission for studying erosion problems of specific localities, the Beach Erosion Board has the mission of making general investigations to determine suitable methods, in general, for the protection, restoration and development of beaches. The study reported herein was made under the part of the Board's general investigations program concerning the results obtained by work completed under shore protection projects and to develop criteria for the design of beach fill projects.

The report was prepared by George M. Watts, Assistant Chief of the Engineering Division of the Beach Erosion Board, under the supervision of Jay V. Hall, Jr., Chief of the Division. The field data utilized herein were obtained by the Bureau of Navigation, Department of Conservation and Economic Development, State of New Jersey, and the Philadelphia District, Corps of Engineers. At the time this report was prepared, the technical staff of the Board was under the supervision of Brigadier General Theron D. Weaver, President of the Board. R. O. Eaton was Chief Technical Advisor. The report was edited for publication by A. C. Rayner, Chief, Project Development Division.

Views and conclusions stated in the report are not necessarily those of the Beach Erosion Board.

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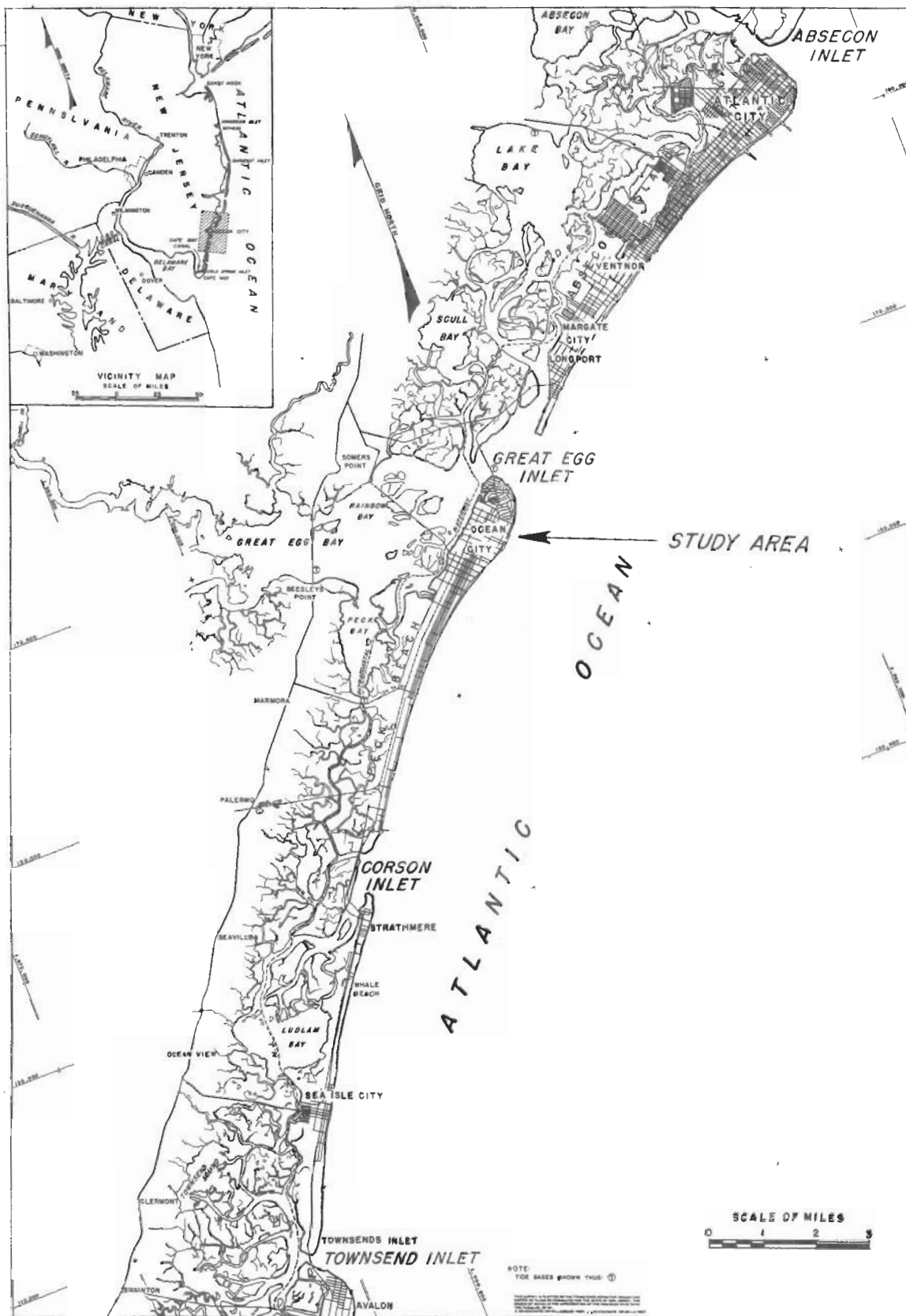


FIGURE 1. LOCALITY MAP, OCEAN CITY, NEW JERSEY

# BEHAVIOR OF BEACH FILL AT OCEAN CITY, NEW JERSEY

by

George M. Watts  
Assistant Chief, Engineering Division  
Beach Erosion Board

## INTRODUCTION

During the years 1949 to 1952, a study of beach erosion at Ocean City, New Jersey was made by the Corps of Engineers in cooperation with the city of Ocean City to determine the causes of the erosion along the Ocean City beach front and the shore of Great Egg Inlet, and to recommend measures for the prevention of further erosion and the restoration of eroded beaches. A comprehensive analysis of the problem led to the conclusion that the most suitable plan of protection for the problem area consisted of artificial placement of suitable sand on the ocean shore and extension of seven existing stone groins. The groin extensions were to be constructed only when experience with the fill should indicate the need therefor. The complete reports on the study are published in House Document No. 184, 83rd Congress. Due to the acute conditions of the beach front at Ocean City, the State of New Jersey and city of Ocean City proceeded promptly toward accomplishment of the beach fill portion of the foregoing plan. The beach fill was initiated in May 1952 and completed in July 1952. The material for the fill was dredged from the tidal waters in back of Ocean City and placed on the ocean beach by pipeline. The total quantity thus placed was about 2,550,000 cubic yards.

In addition to the basic hydrographic survey of 1949 made during the study of the erosion problem, surveys of the beach and offshore zones were made at intervals after placement of the beach fill. The dates of surveys were August 1952, March, July and October 1953 and March 1955. The present study analyzes the periodic field survey data with a view to evaluating the movement and effectiveness of the beach fill.

## SUMMARY OF PHYSICAL DATA\*

Ocean City is a popular summer resort, located about 130 miles south of New York City and about 35 miles northeast of Cape May, which is the southern tip of the State of New Jersey at the entrance to Delaware Bay. The locality is shown on Figure 1. Ocean City occupies the entire length of a barrier beach island, about 8 miles in length, bounded on the northeast and southwest by Great Egg and Corson Inlets, respectively. The greatest development of the island is near Great Egg Inlet.

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\* Summarized from report of District Engineer, Corps of Engineers, Philadelphia, Pa., published in House Document No. 184, 83d Congress.

The barrier beaches of New Jersey coast are composed of materials eroded from the mainland. These formations tend to retreat landward as a result of wave and wind action, thus gradually overriding the marshes and filling the lagoons in the rear. As indicated by sand samples taken at Ocean City in February - March 1949, the beach was composed of sand of medium size. Offshore samples generally revealed a finer sand; however, in some offshore zones the material was comparable to the beach sand and in a few cases even coarser than the beach sand.

The tides at Ocean City are semi-diurnal, the mean range being about 4 feet. It was reported that during the hurricane of September 1944 the tide at Ocean City reached a record height of approximately 10 feet above mean low water.

In 1949 drift floats were utilized to observe directions and velocities of currents in Great Egg and Corson Inlets (see Figure 3). The observations were made during the strengths of current and under various conditions of wind and tide. On ebb tide at Great Egg Inlet it was found that the principal part of the flow moved through the gorge of the inlet with maximum velocities of about 4 feet a second, decreasing to about 2 feet a second as the flow moved seaward and eventually parallel to the Ocean City shore. The maximum flood current velocities observed were between 2 and 3 feet a second in the deeper part of the channel. Data obtained at Corson Inlet indicated that the currents at this inlet are considerably weaker than those at Great Egg Inlet, the strength being about 2 feet a second.

The prevailing winds at Ocean City, based on observations from 1923 to 1949 at Atlantic City about 8 miles to the northeast, were from the south, with winds from the west of secondary importance. The winds of greatest average velocity (19 miles an hour) were from the northeast. Winds of 60 miles an hour or more occur on an average of a little more than once a year. The maximum wind velocity of 5-minute duration recorded at Atlantic City was 82 miles an hour from the north during the hurricane of September 1944.

Wave height and direction observations were made at various locations along the Ocean City shore line from October 1948 to October 1949. Observed wave heights ranged from a minimum of nearly zero to a maximum of 8 feet. The average for all observations was a height of 2.3 feet. Considerable differences in direction were observed. These differences were attributed to differences in offshore hydrography and, in part, to the influence of tidal flow through the inlets.

The various positions of the Ocean City shore line for the period 1842-1949 are shown on Figure 2. The history of the Ocean City frontage from Great Egg Inlet to 14th Street indicates a progressive advance oceanward and toward the inlet. Short term retreats of the shore line occurred, particularly between 1944 and 1949, however the net change over the entire record indicates considerable accretion on both the ocean and

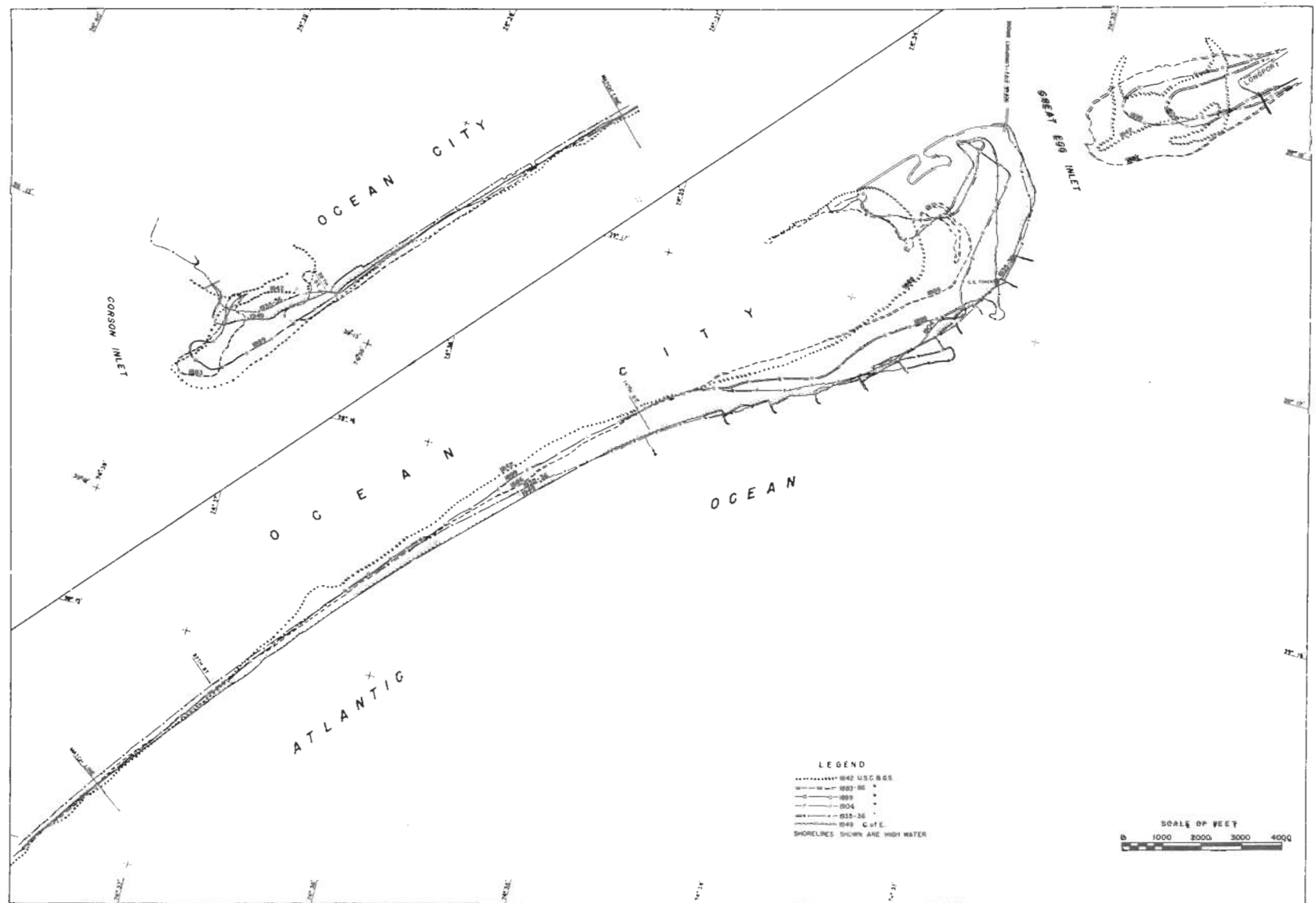


FIGURE 2. HIGH WATER SHORE LINE CHANGES, 1842-1949- OCEAN CITY, NEW JERSEY



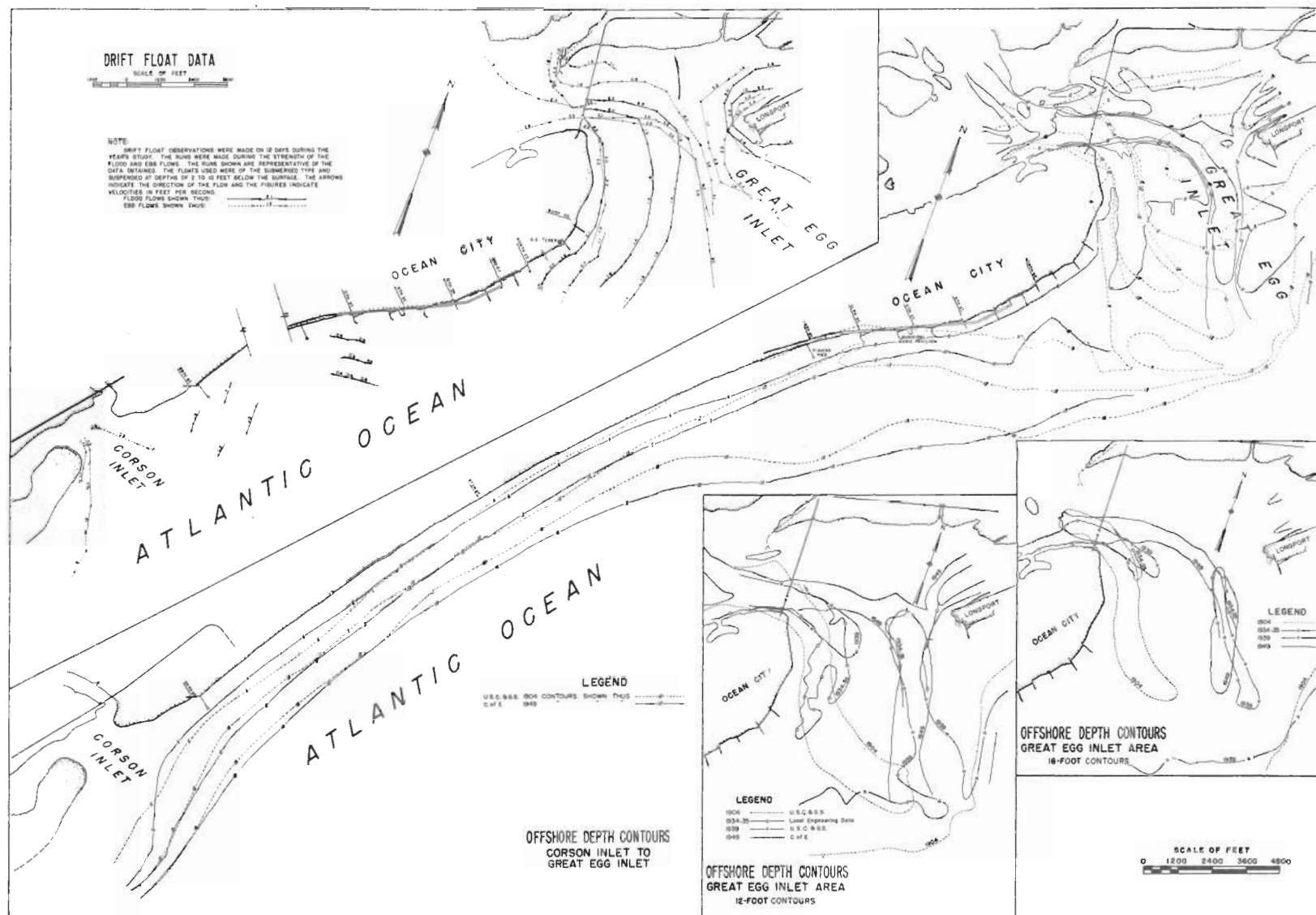


FIGURE 3. OFFSHORE DEPTH CONTOURS, 1904-1949 AND DRIFT FLOAT DATA-OCEAN CITY, NEW JERSEY

inlet fronts. From 14th Street to 37th Street the shore line advanced oceanward in varying amounts over the period 1842-1949; however, from 37th Street to Corson Inlet the overall net change, during the period, was a recession of the shore line.

The comparative hydrography at Great Egg Inlet and southwest thereof indicates that for the period 1904 to 1949 there was migration of the channel and shifting of bars and shoals. Figure 3 shows the northeastward migration of the main channel and changes of the 6, 12 and 18-foot depth contours during that period.

A study of the New Jersey coast from Barnegat Inlet to Cape May reveals that the predominant movement of littoral drift is generally from northeast to southwest. Along the Ocean City shore line, except in the immediate vicinity of Great Egg Inlet, studies indicate that the predominant drift direction is also in that direction. The structures along the Great Egg Inlet frontage of Ocean City have collected more sand on their oceanward than on their bayward sides, which indicates a predominant movement of littoral drift at this point toward the inland waters. The structures located on the ocean frontage have collected the greater volume of sand on the northeast sides. No data are available to establish the annual rate of littoral drift along the Ocean City shore line; however, studies of erosion at Atlantic City have indicated that 400,000 cubic yards may be accepted as a reasonable estimate of the annual rate at which material moves to the southwest from that locality. The beaches between Atlantic City and Ocean City have been generally stable for some years and it has been assumed that an average of about 400,000 cubic yards per year reaches the region of Great Egg Inlet.

Protective works were constructed along the Ocean City shore line as early as 1907, however of fifty-two groins of various types that have been built only eleven rubble-mound groins are now in reasonably good condition. These rubble-mound structures, located as shown on Figure 4A, are of relatively recent construction.

An analysis of the physical conditions in the Ocean City area indicates that there were several reasons for the recession of the shores in the last two decades. As a result of northeastward shifting of the channel of major flow of Great Egg Inlet into the shoal area that projected from the Longport tip of Absecon Island, large quantities of sand were available for deposition on the Ocean City shores. Protective construction on the Longport tip of the inlet prevented further migration of the main channel, with a result that the channel deepened and the littoral movement of sand to the Ocean City beaches was reduced. The reduced supply of material was insufficient to maintain the advanced position of the Ocean City shore. As a result the shore line between Surf Road and 12th Street receded since 1930. Based on the most reliable data available, the loss between 1930 and 1950 was estimated at about 1,000,000 cubic yards, or at an annual rate of about 50,000 cubic yards.

### PLAN OF PROTECTION

The 1949-1952 beach erosion study indicated that the acute erosion problem extended from Seacliff Road on Great Egg Inlet to 12th Street on the ocean beach. The inlet shore west of Seacliff Road is protected from further erosion by a longshore rubble-mound seawall, and the shore south of 12th Street was considered to have adequate width to protect shore front property. As a result of the study a plan of protection and improvement for the shore from Surf Road to 12th Street was recommended. This plan comprised artificial placement of suitable sand fill to widen the beach to a width of approximately 300 feet between the boardwalk or bulkhead and the mean high water line. The anticipated beach slopes landward and seaward of the high water line, respectively were 1 on 50 and 1 on 30. The estimated volume of sand required for the fill between Surf Road and 12th Street was 1,900,000 cubic yards. An additional 230,000 cubic yards would have been required to restore the beach from Surf Road to Seacliff Road.

In the frontage between Seaspray Road and 12th Street there are eleven groins of rubble-mound construction. The recommended artificial fill would advance the high water line to or near the ocean ends of those groins. It was realized that the existing groins would not be as effective in retaining the fill in its advanced position as it was in reducing losses from the natural beach. An initially higher rate of loss could possibly be reduced by seaward extension of some of the groins. The estimated first cost of 1,900,000 cubic yards of fill was \$1,429,000. Seaward extension of seven of the eleven groins by 210 to 405 feet was estimated to cost an additional \$453,000. With an estimated rate of loss in this area of 50,000 cubic yards annually, it was assumed that the rate of loss with groin extensions would be the same. The estimated annual charges of the groin extensions were \$37,240, and if annual cost of replenishment (50,000 cubic yards) was \$44,000, the total annual costs for groin extensions and maintenance fill would be \$81,240. If the annual cost of maintenance without groin extensions would not exceed \$81,240, the groin extensions would not be justified. This sum would place an average volume of approximately 100,000 cubic yards of fill annually, or twice the estimated rate of loss prior to placement of fill. It was considered that the required maintenance would be less than 100,000 cubic yards annually without groin extensions, and it was therefore the Beach Erosion Board's opinion that maintenance costs by placement of fill alone should be determined before the groins were extended.

### PLACEMENT OF BEACH FILL

The State of New Jersey, in cooperation with the city of Ocean City, had the beach fill placed by contract from May to July 1952. The fill material was taken from the bay area in back of Ocean City; in general, the bay borrow area extended between North and 8th Streets. The quantity of fill placed on the beach by pipeline, as measured in the borrow area, was approximately 2,550,000 cubic yards. The beach fill extended

from the Atlantic Boulevard groin to 13th Street. The fill was distributed on the beach between these points. The greatest proportion, approximately 22 percent of the total, was placed between the 3rd and 5th Street groins. The minimum fill berm elevation was 8 feet above mean low water, and the width of the berm ranged from 80 to 300 feet. The fill berm was leveled to meet the existing berm elevation and the seaward face or foreshore was permitted to take a natural slope.

#### SURVEY DATA

The latest survey of conditions in the beach fill area made prior to placement of the fill was that of March 1949. It extended from Great Egg Inlet to Corson Inlet and to about the 24-foot depth. Figure 4 shows the depth contours from this survey. The next survey, which extended from Atlantic Boulevard to 14th Street and to about the 12-foot depth, was made in August 1952, almost immediately after the fill was completed. Its depth contours are shown on Figure 5. A survey covering the area from Seaview Road to 14th Street and to about the 18-foot depth was made in March 1953. Its contours are shown on Figure 6. Surveys which extended from Seaview Road to 23rd Street and to about the 18-foot depth were made in July and October 1953. Their depth contours are shown on Figures 7 and 8, respectively. A survey which extended from Great Egg Inlet to Corson Inlet and to about the 24-foot depth was made in March 1955; depth contours of this survey are shown on Figure 9. Aerial photographs showing the beach fill area and adjacent frontage were taken in April and August 1952, April 1953 and October 1954; these photographs are shown as Figure 10.

Along the Ocean City frontage, sand samples were taken at various points along the berm crest in December 1929; along the mid-tide line in August 1932 and July 1935; along the mid-tide line and offshore in March and October 1949; along the high water line in July 1950; and along the berm, high water, mid-tide, low water lines, 12, 18, 24 and 30-foot depths in June 1953. In March 1955 samples were taken from an area landward of the boardwalk. These samples were believed to represent undisturbed 1952 fill material. Also in March 1955 bottom samples were obtained from the bay area from which the 1952 fill had been obtained. Additional bottom samples were taken from a shoal in the immediate vicinity of the 1952 bay borrow area. During the filling operation twelve samples were taken by the contractor from the discharge end of the pipeline. The State provided the analysis of one sample which was taken 100 feet behind the high water line. This sample was marked as being representative of the 1952 beach fill. Table 1 lists the median diameters of samples taken from 1929 to 1953. Table 2 gives the average size distribution (percentage retained on sieves) for samples taken in 1952 and 1955.

#### ANALYSIS OF DATA

The August 1952 survey, which was made almost immediately after the fill was placed on the beach, covered approximately the shore within the



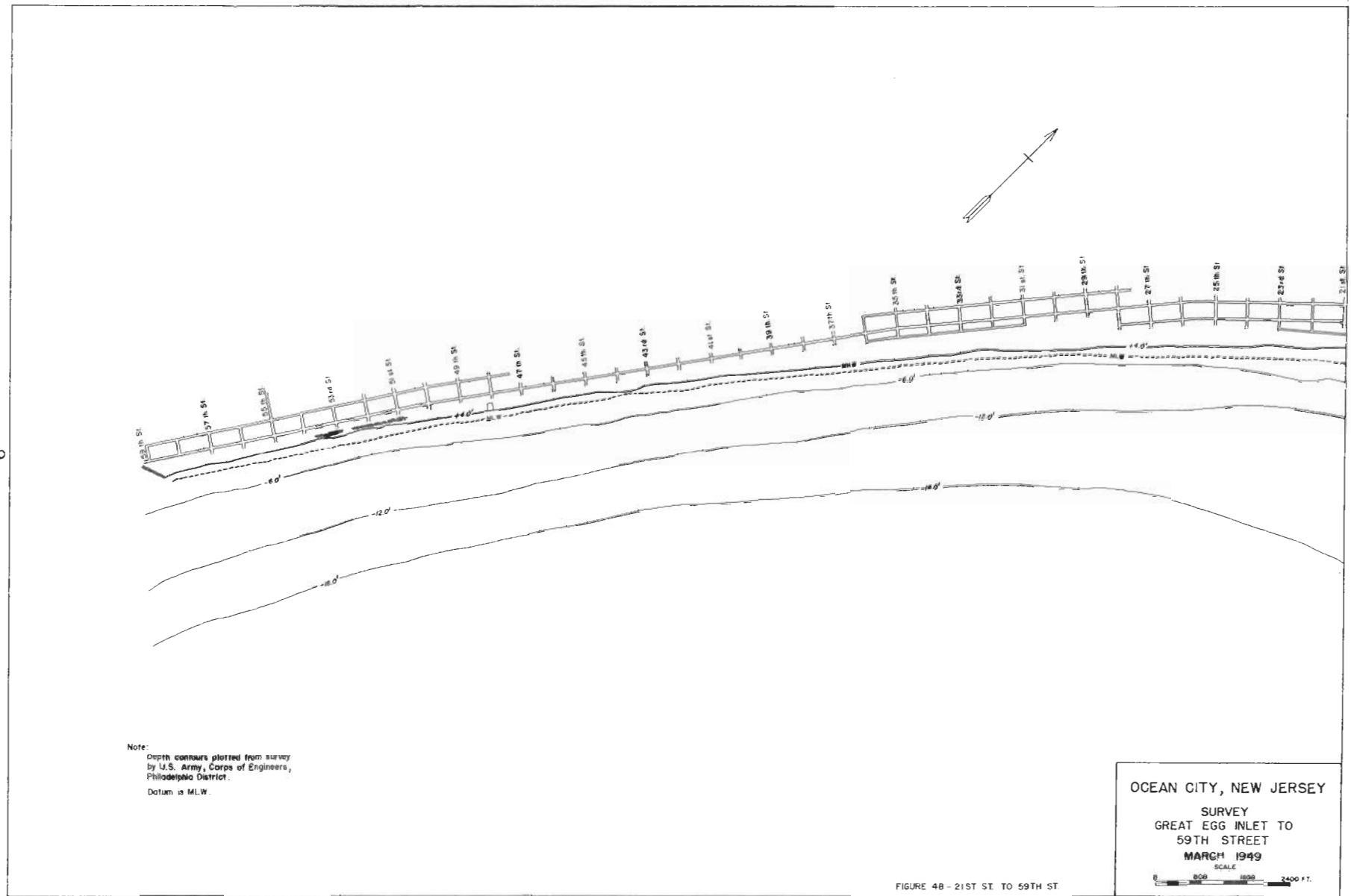


FIGURE 4B

FIGURE 4B - 21ST ST. TO 59TH ST









FIGURE 7

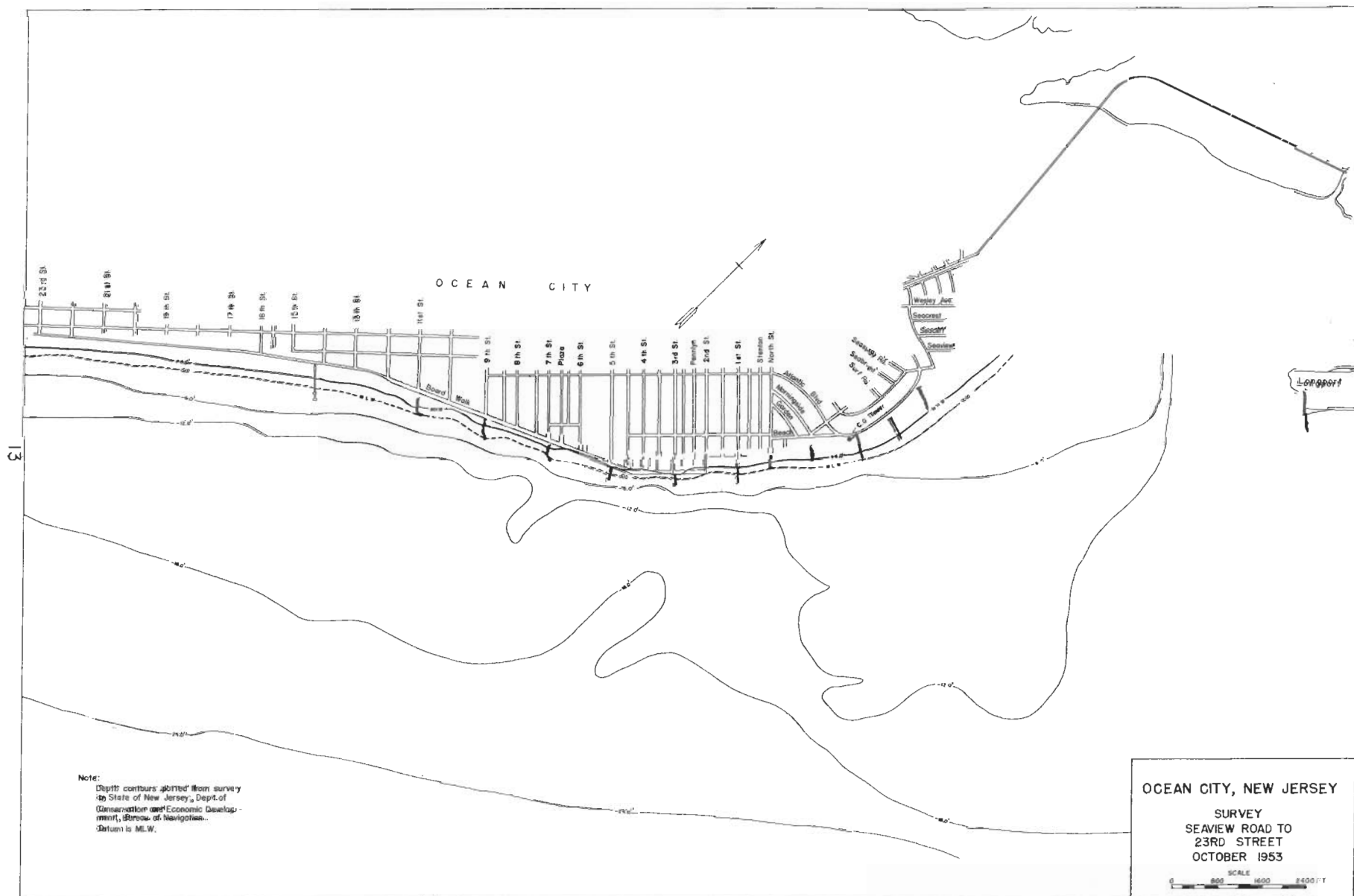


FIGURE 8



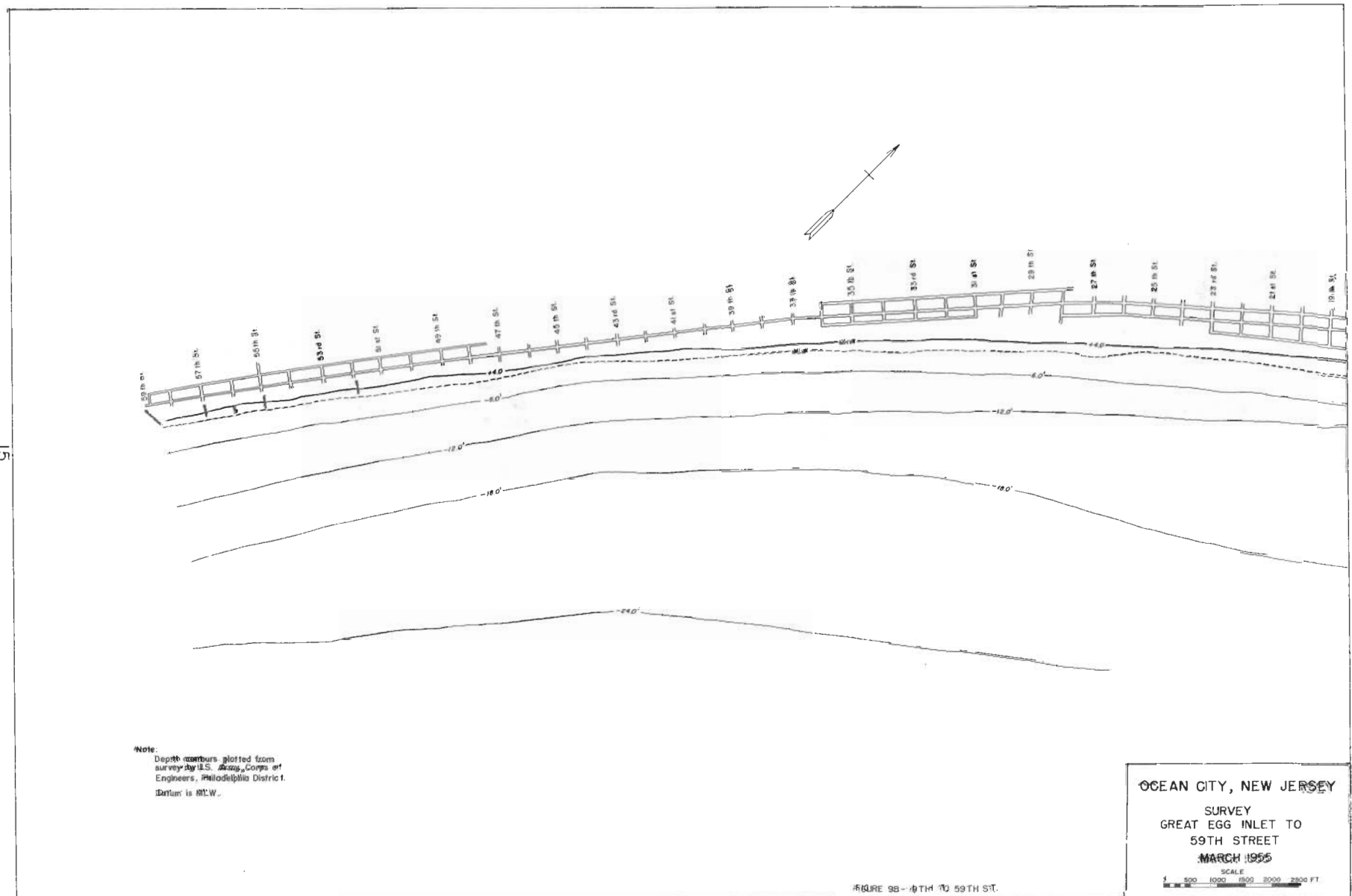


FIGURE 9B - 4TH TO 59TH ST.

FIGURE 9B



FLOWN BY LOCKWOOD, KESSLER & BARTLETT, INC.

APRIL 16, 1952 (Prior to fill placement)



FLOWN BY RAYNOR AERIAL SURVEYS

AUGUST 11, 1952 (Subsequent to fill placement)



FLOWN BY LOCKWOOD, KESSLER & BARTLETT, INC.

APRIL 15, 1953



FLOWN BY RAYNOR AERIAL SURVEYS

ALL AERIAL PHOTOGRAPHY  
FURNISHED BY STATE OF  
NEW JERSEY.

OCTOBER 12, 1954

FIGURE 10. OCEAN CITY, NEW JERSEY- COMPARATIVE PHOTOGRAPHY

Table 1 - SAND SAMPLE ANALYSIS DATA

Date	General Location of Sample	Median Diameter (millimeter)									
		Berm Crest	HWL	MTL	LWL	-10 ft.	-12 ft.	-18 ft.	-24 ft.	-30 ft.	Other
Dec. 1929	Seaspray Rd.	0.31									
"	1st Street	0.19									
"	So. of 11th Ave., Longport	0.20									
"	Great Egg Inlet Ebb Channel										0.41
"	Great Egg Inlet Ebb Channel										0.12
Aug. 1932	Surf Rd.			0.25							
"	25th Street			0.20							
"	42nd Street			0.24							
"	Approx. 59th Street			0.24							
"	11th Ave., Longport			0.23							
July 1935	25th Street			0.20							
"	So. of 11th Ave., Longport			0.18							
Mar. 1949	Wesley Rd.			0.23		0.19					
"	Atlantic Blvd.			0.21		0.25					
"	8th Street			0.22		0.15					
"	23rd Street			0.22		0.14					
"	59th Street			0.22		0.25					
Oct. 1949	Wesley Rd.			0.23		0.23					
"	Atlantic Blvd.			0.22		0.22					
"	8th Street			0.17		0.15					
"	23rd Street			0.16		0.12					
"	59th Street			0.16		0.13					
July 1950	1st Street		0.17								
"	12th Street		0.18								
"	19th Street		0.17								
"	30th Street		0.18								
"	40th Street		0.19								
"	50th Street		0.18								
"	59th Street		0.21								
June 1953	5th Street	0.19		0.18		0.13	0.11	0.09	0.08		
"	8th Street			0.30	0.19	0.12	0.11	0.10	0.10		
"	9th Street	0.17	0.24			0.12	0.10		0.08		
"	14th Street		0.17	0.21		0.12	0.10	0.12			

TABLE 2 - SAND SAMPLE ANALYSIS DATA (AVERAGES)

<u>Sample Location</u>	<u>Sieve Opening (millimeter)</u>						<u>Pan</u>	<u>Median Diameter (mm.)</u>
	<u>0.297</u>	<u>0.210</u>	<u>0.149</u>	<u>0.105</u>	<u>0.074</u>	<u>0.062</u>		
<u>Percent retained on sieves</u>								
May-July 1952, Dis- charge pipe, 12 samples	19.0		76.7		3.8		0.4	0.23
May-July 1952, Fill in place, 1 sample	6.0	22.0	45.0	25.0				0.18
March 1955, former borrow area, 7 samples	0.4	1.9	21.3	54.6	12.0	2.3	7.4	0.13
March 1955, Shoal near former borrow area, 5 samples	2.1	13.7	45.1	34.2	4.2	0.5	0.3	0.16
March 1955, undisturbed fill on present shore, 3 samples	7.1	13.9	38.4	33.8	5.1	0.7	0.9	0.16

fill limits (Atlantic Boulevard to 13th Street) and out to about the 12-foot depth. The coverage of this survey permits only limited evaluation of the movement of beach materials between March 1949 and August 1952, and of the fill movement from August 1952 to March 1953. The net depth changes between March 1949 and August 1952, based on the respective surveys (Figures 4 and 5) are shown on Figure 11. This comparative depth-change plot shows the result of placement of the fill within the fill limits. By utilizing comparative profiles (Figure 17) and extrapolating elevations from mean high water (+4 feet) to about +8 feet for the two surveys, it was computed that the volume of material from Atlantic Boulevard to 13th Street and out to about the 12-foot depth in August 1952 exceeded the volume in that area in March 1949 by approximately 2,100,000 cubic yards. Since the quantity of fill placed on the beach was about 2,550,000 cubic yards, this would indicate some 450,000 cubic yards were involved in the onshore and offshore zones beyond the 1952 survey limits or were lost from the fill area between March 1949 and August 1952. It is apparent that some fill material was placed landward of the March 1949 and August 1952 survey limits, and undoubtedly a substantial volume of material was transported beyond the 12-foot depth (particularly the finer fractions of the fill material) during filling operations. If both these factors are taken into account, the 450,000-cubic yard loss for the 3.4 years would probably be reduced to a value comparable to the annual loss rate for the 1930-1950 period (50,000 cubic yards). The fact that no survey was made of the area immediately prior to placement of fill, coupled with the limited coverage of the first survey after placement of fill (August 1952), limits a quantitative approach to the evaluation of material movement between March 1949 and August 1952. Figure 11 shows depth changes of as much as 10 feet near the end of the groin at 3rd Street; if the analysis of data for loss of material between March 1949 to August 1952 is of the right order of magnitude, the actual depth of fill probably exceeded 10 feet in some places.

A comparison of the August 1952 and March 1953 surveys is shown by the depth-change plot in Figure 12. The comparison indicates that a substantial quantity of material was moved out of the fill area, the maximum depth increase being about 9 feet. Some accretion is indicated in the offshore zone. Limits of the August 1952 survey preclude an evaluation of alongshore material movement. A comparison of the depth changes on Figure 11, which relates the March 1949 and August 1952 surveys, and Figure 12 produces strong evidence that a large percentage of the fill material was moved out of the fill area beach zone during the 7 months after placement of fill. Comparison of Figures 4 and 6 indicates that near 3rd Street the position of the mean high water line was nearly as far landward of the boardwalk in March 1953 as in March 1949.

Figure 13, presenting the depth changes from March 1953 to July 1953, indicates general erosion in the offshore zone within the fill limits, and general accretion along the shore in both directions beyond the fill limits. Considering the depth changes from March to July 1953 (Figure 13),

the data would indicate that during the first 7 months after placement of fill, the material was rapidly transported to the immediate offshore zone and probably to some extent alongshore, thereafter, for the next 4 months the net material movement was that of onshore combined with alongshore movement.

Figure 14, presenting the depth changes from July to October 1953, indicates a continuation of the same net material movement as indicated between March and July 1953, namely, general offshore erosion, slight erosion of the shore within the fill limits and accretion of material along the shore in both directions beyond the fill limits. Limited data are available in Figures 13 and 14 relative to the depth changes of offshore zones in Great Egg Inlet, however the data shown indicate extremely large quantities of material were transported in and around the ebb and flood channels of the inlet.

Figure 15 presents the depth changes from October 1953 to March 1955. During this period there was general erosion throughout the fill area and accretion in both directions beyond the fill limits. The data indicate that the rate of accretion in the inlet direction from Atlantic Boulevard and southwest of 14th Street was much lower than that between August 1952 and October 1953. The depth changes in the offshore zones from October 1953 to March 1955 (Figure 15) indicate substantial movement of material in the offshore area.

Figure 16, presenting the depth changes from March 1949 to March 1955, indicates that along the shore between Atlantic Boulevard and approximately Wesley Avenue there has been substantial accretion over the 6-year period. Southwest of the fill limits, between about 14th Street and 35th Street, there has been accretion. In general, within the 1952 fill limits (Atlantic Boulevard to 13th Street) the net depth change is less than 1 foot, which would indicate that the shore along this sector should have been in about the same condition in March 1955 as it was in March 1949. Further evidence of this is that the plan area between the March 1949 and August 1952 mean high water lines, between Atlantic Boulevard and 13th Street, was +3,243,000 square feet, and for the same limits between August 1952 and March 1955 the plan area was about -3,092,000 square feet (plot of comparative mean high water lines not shown). In the offshore zones, marked erosion and accretion occurred between March 1949 and March 1955. Erosion was prevalent offshore of 4th Street, Atlantic Boulevard, and throughout the main ebb channel of Great Egg Inlet. Some accretion is indicated offshore of 1st Street, and substantial accretion offshore and immediately south of the ebb channel of Great Egg Inlet. The depth changes plotted on Figure 16 indicate that the volume of material moved in the offshore zones, particularly in the immediate inlet area, has apparently been many times the volume of fill placed on the beach in 1952. It is evident that the data are not sufficiently detailed to evaluate accurately the quantitative



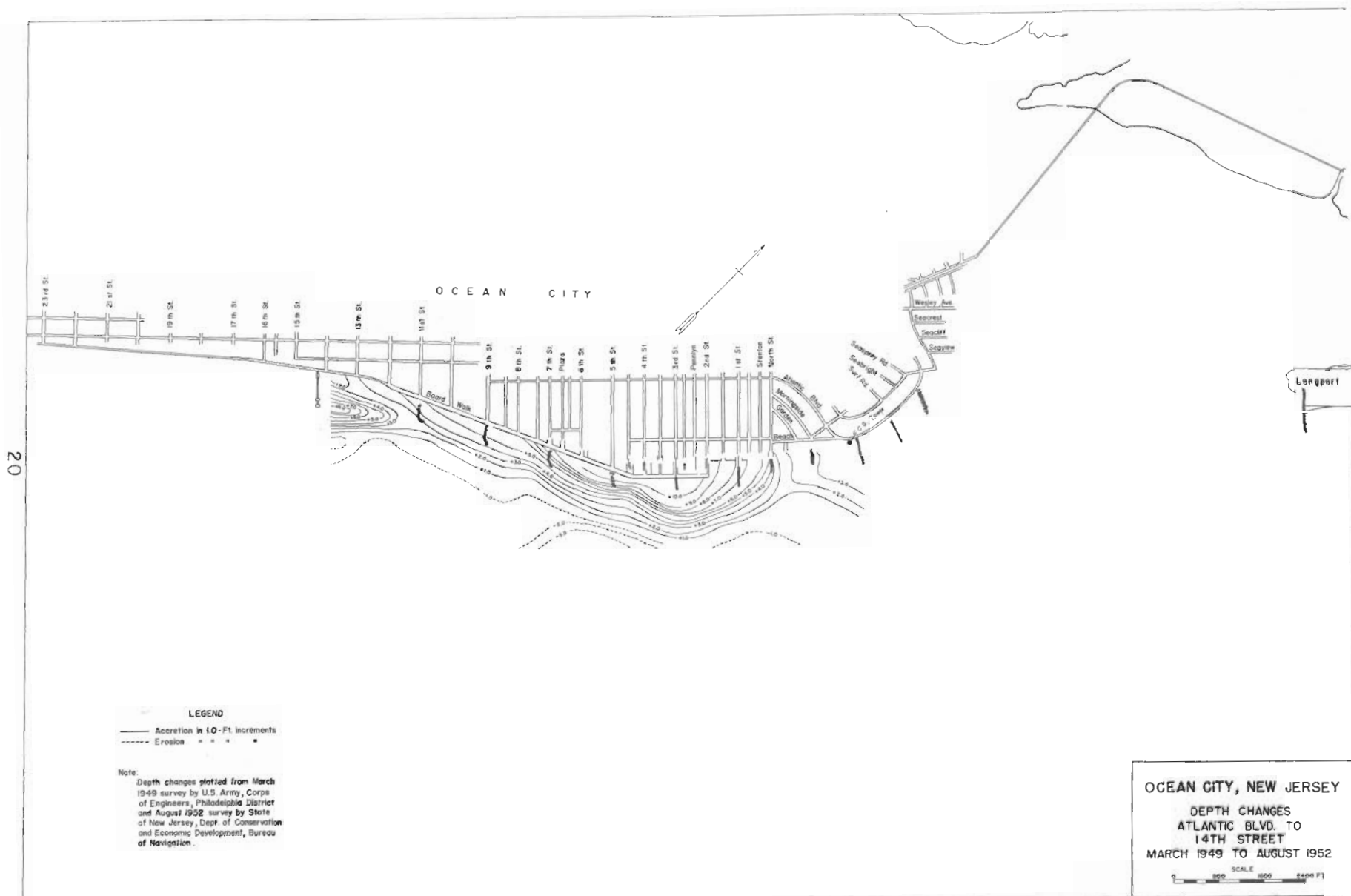


FIGURE 11

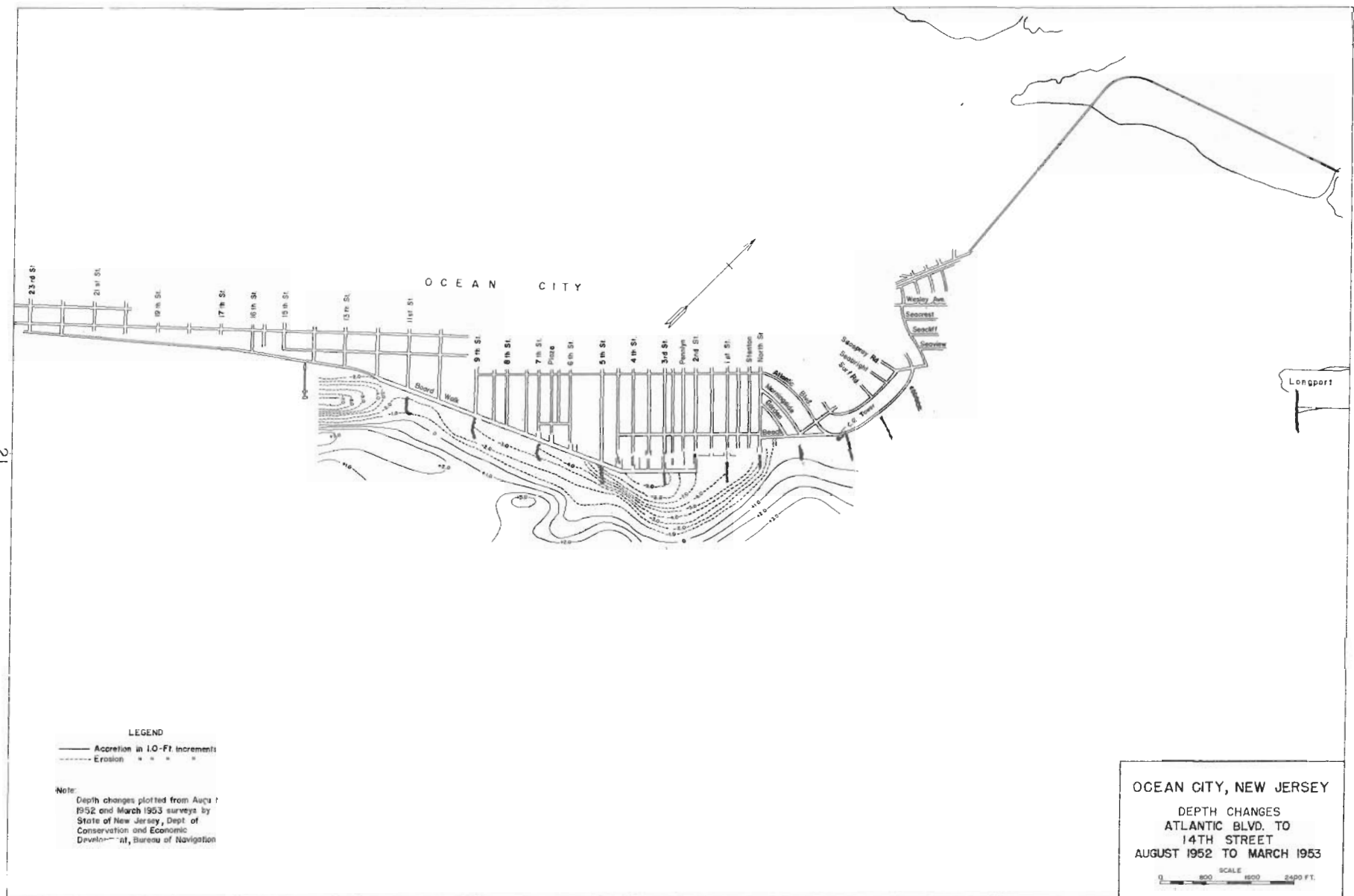


FIGURE 12

FIGURE 13

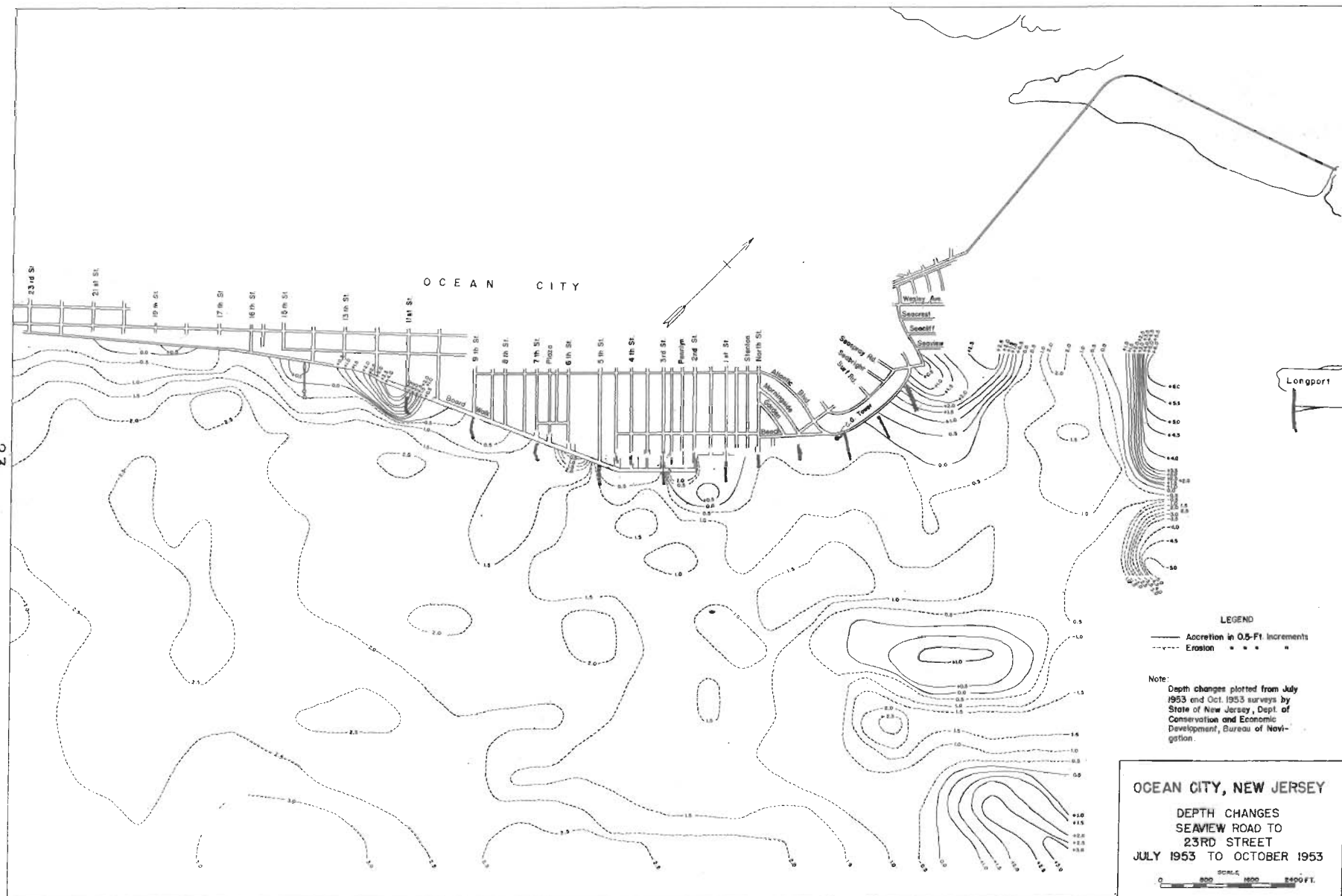


FIGURE 14

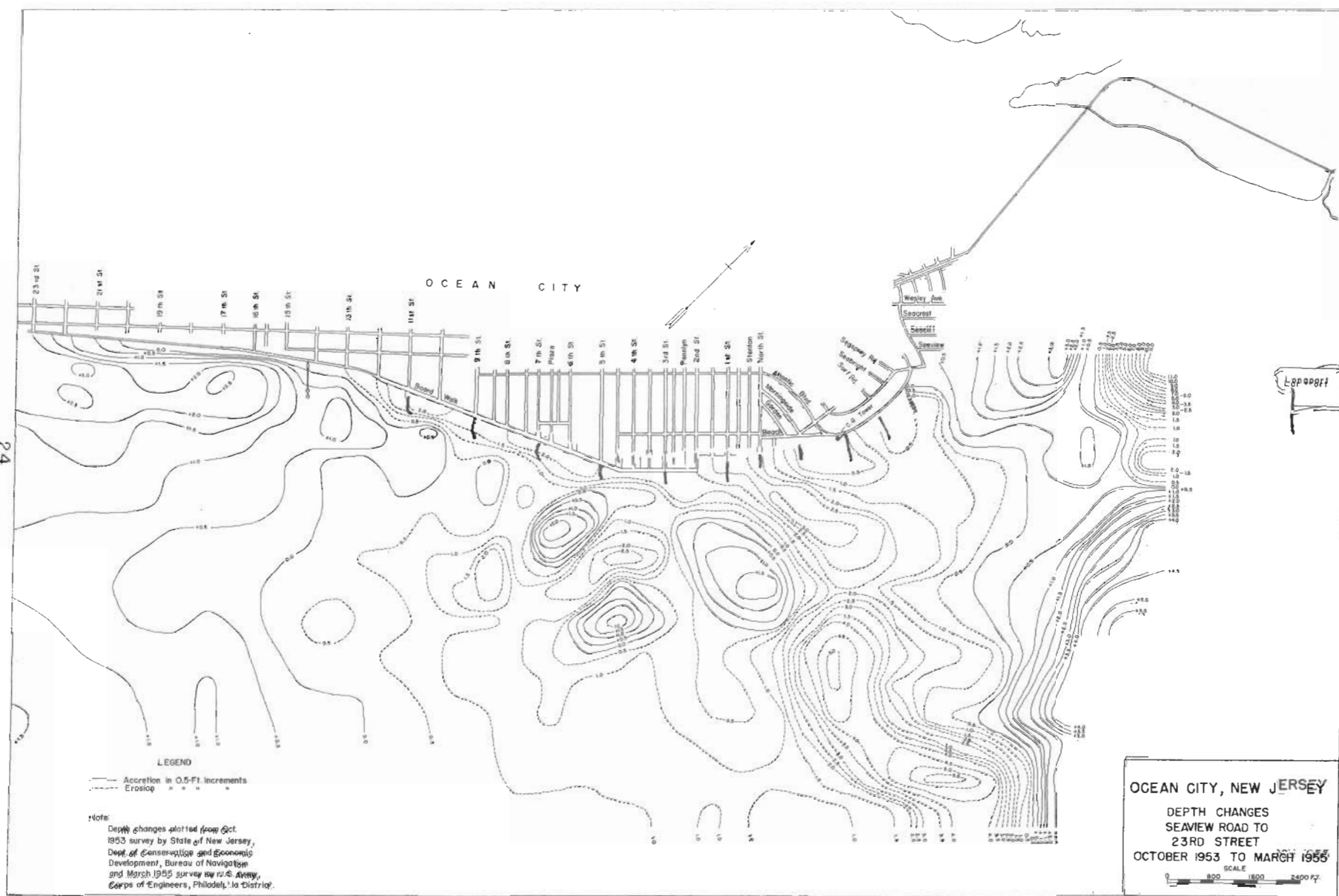


FIGURE 15

FIGURE 16A

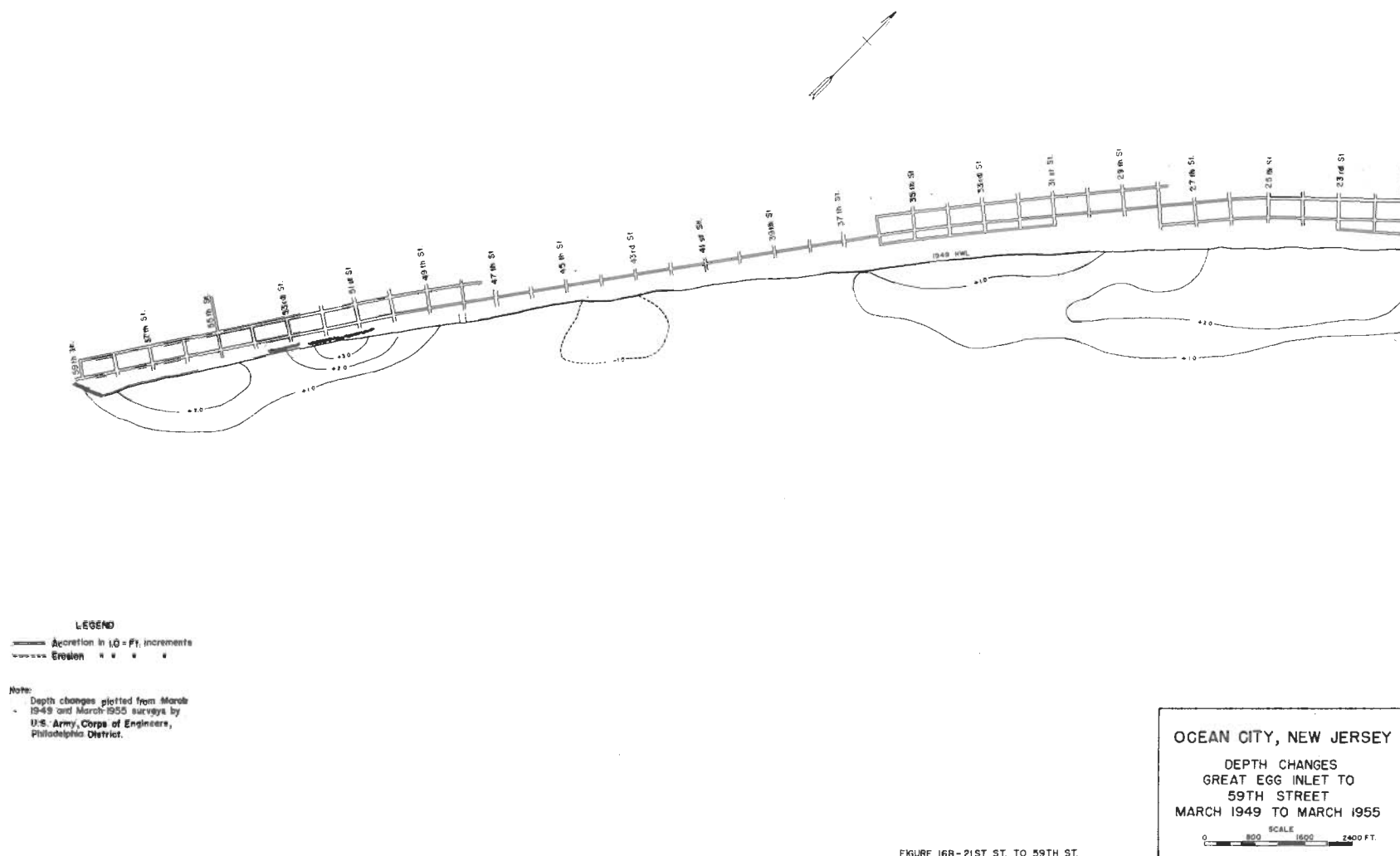


FIGURE 16B-21ST ST. TO 59TH ST.

FIGURE 16B

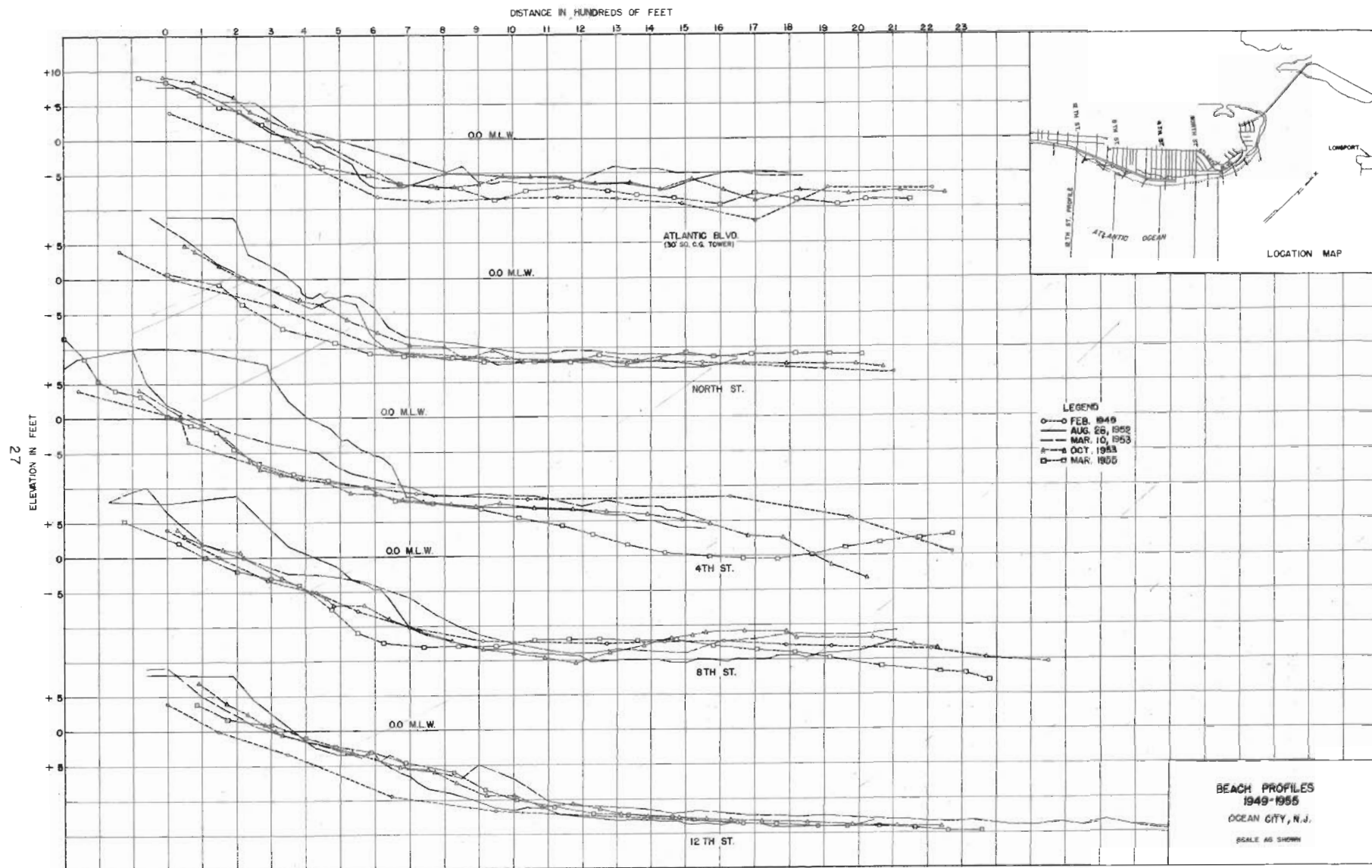


FIGURE 17



movement of the beach fill and to determine the relative effects of wave action and tidal currents of Great Egg Inlet in this movement. The data are sufficiently detailed to make qualitative analysis of the material movement along the shore and, to some extent, of the material movement in the offshore zones. In terms of approximate volumes to aid in evaluating the qualitative features of the problem area between March 1949 and March 1955, it was computed within the limits of the surveys that a volume of about 1,000,000 cubic yards of material was gained along the shore between the Coast Guard tower and Wesley Avenue; another million cubic yards of material was gained along the shore southwest of the fill limits or between about 14th Street and 35th Street. In the zone offshore from about 4th Street erosion amounted to approximately 900,000 cubic yards of material and immediately to the northeast of this eroded zone (about 1st Street) accretion was about 275,000 cubic yards. The erosion zone offshore of Atlantic Boulevard lost about 1,200,000 cubic yards, and northeast of this erosion zone an accretion of about 1,150,000 cubic yards occurred; this accretion is undoubtedly related to the material eroded from the main ebb channel of Great Egg Inlet, as it is indicated that about 3,500,000 cubic yards were eroded from that channel over the 6-year period.

Figure 17 is a plot of beach profiles from Atlantic Boulevard to 12th Street. A comparison of the August 1952 to March 1955 beach profiles was made to investigate the relative rate at which the fill material had moved out of the nearshore zone of the fill limits. Elevations landward of mean high water (+4 feet) were not given on several of the intermediate surveys therefore only losses to comparative high water lines could be considered. The following tabulation shows the material movement between the Atlantic Boulevard groin and 13th Street:

Surveys	MHWL to MLWL Cu. yds.	MLWL to -6 feet Cu. yds.	-6 feet to -12 feet Cu. yds.	Net Change MHWL to -12 feet Cu. yds.
8/52 to 3/53	-359,000	- 8,000	+330,000	-37,000
3/53 to 10/53	- 88,000	-176,000	-339,000	-603,000
10/53 to 3/55	-224,000	-234,000	-575,000	-833,000
8/52 to 3/55	<u>-671,000</u>	<u>-418,000</u>	<u>-384,000</u>	<u>-1,473,000</u>

The above volumetric computations tend to support the qualitative data, exhibited in Figures 11 through 16, that a substantial volume of fill material was initially moved offshore and thereafter onshore and along-shore movement occurred. The computations also provide supporting evidence that the loss of material between mean high and low water lines or redistribution of this material during the first 7 months after placement of fill was at a relatively high rate, apparently several times the annual rate (total movement) normally associated with this sector of shore.

Figure 18 is a comparative plot of selected profiles from the March 1949 and March 1955 surveys. The comparative profiles depict the shore

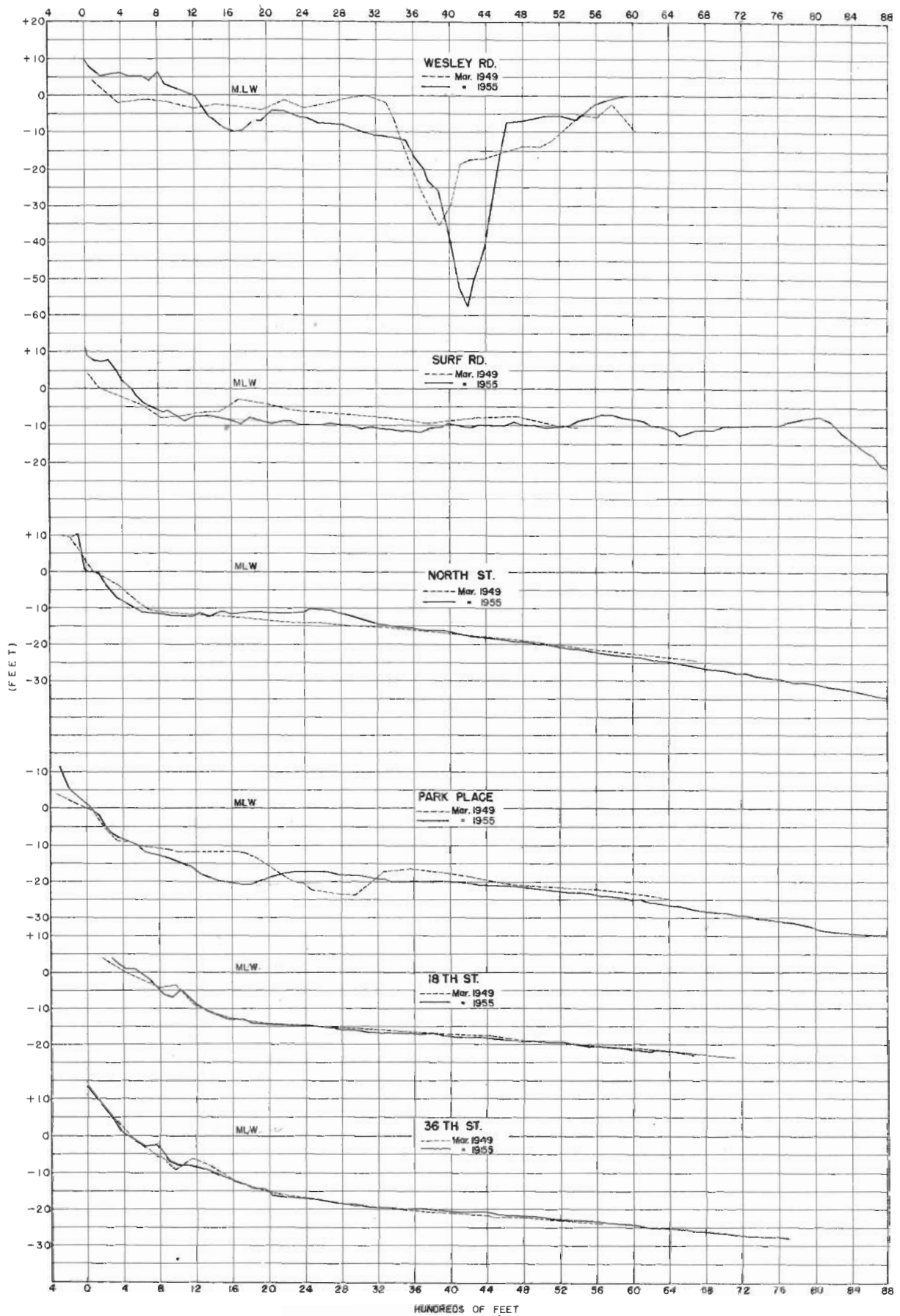


FIGURE 18 · COMPARATIVE PROFILES, OCEAN CITY, NEW JERSEY

accretion northeast and southwest of the fill limits and the similarity of foreshore and nearshore bottom slopes within the fill limits between 1949 and 1955. The comparative profiles for offshore hydrography in this plot further illustrate the net material movement as shown in the depth-change plot of Figure 16.

An analysis of the sand sample data from 1932 to 1949, as presented in Table 1, indicates that the median diameter of the sand at the mid-tide line in the area was about 0.23 millimeter. The size gradation, Table 2, of material placed on the beach (samples from the borrow area and remnants of the remaining fill) reveal that the fill material probably had a median diameter of around 0.16 millimeter. The average value (0.23 mm.) of the median diameter obtained from the twelve samples collected by the dredging company appears high, relative to all other borrow material size data. This may be the effect of sampling at the discharge end of the dredge line, samples probably containing a preponderance of the coarser fraction which would normally flow along the bottom of the pipe. The data in Table 2 indicate that the material used for fill was substantially finer than that composing the more stable beaches in this region. The greater part (75 to 80%) of the fill material was between 0.1 and 0.2 millimeter in size, which is essentially in the fine sand classification. A comparison of the 1949 and 1955 profiles indicates that the beach slopes are comparable, which strongly suggests that a major portion of the finer fractions of the fill material was transported out of this zone (this action being very rapid as indicated by the periodic surveys) leaving a residual of sizes comparable with that comprising the beach zone before fill was placed. Assuming that a major portion of the finer fractions of fill material would be shifted from the foreshore to the offshore area by selective sorting during slope adjustment, about 50 percent of the 0.16-millimeter median diameter fill material would have to be lost from the foreshore zone to bring remaining foreshore material to 0.20-millimeter median diameter, and 75 percent to bring it to 0.23-millimeter median diameter, which approximates the size of the natural material on the beach in this shore segment.

#### DISCUSSION

The rate of material movement for the period March 1949 to August 1952 cannot be firmly established from available data. There is no reason to believe that the loss of material from the problem area during this period was at a lower rate than that between 1930 and 1949, or about 50,000 cubic yards annually. If this rate of loss is of the right magnitude, lesser importance can be placed on the fact that a survey of the study area was not made immediately before the fill operations were started (May 1952). It means, in this case, that the required fill, as computed on the basis of the March 1949 survey, should have been increased by approximately 150,000 cubic yards to compensate for the losses between

March 1949 and May 1952. On this basis the volume of suitable material required to create the desired beach width would have been 2,050,000 cubic yards, rather than 1,900,000 cubic yards, the estimated quantity based on the 1949 survey.

The material used for the 1952 beach fill was finer than that composing the natural beaches in the study area. The fact that a large percentage of fill material did not remain on the foreshore indicates that there was an insufficient quantity of material in the coarser sand fractions, therefore only part of the borrow material remained as residual beach material. As computed in the previous paragraph, 2,050,000 cubic yards of suitable material would have been required to create the desired beach width. In order to have a residual after sorting by wave action of 2,050,000 cubic yards of material with median diameter of 0.23 millimeter, placement of about 4,750,000 cubic yards of the material of the quality actually placed would have been required. This requirement is about 2,200,000 cubic yards greater than the volume actually placed.

The rate at which material was transported out of the fill area was high. Considering the 2.6-year period between August 1952 and March 1955, the annual rate was nearly 1,000,000 cubic yards. The data indicate that the loss from the beach or shore zone during the first 7 months after placement of fill was probably at a higher rate than the overall average, and that from March 1953 to March 1955 the rate decreased substantially. The March 1955 survey indicates the mean high water line to be from 10 to 150 feet landward of the boardwalk in many places between Atlantic Boulevard and 13th Street, a recession of from 100 to 400 feet since August 1952. This would indicate that (with the existing groins in the area) placement of comparable quality fill must be accomplished at frequent intervals in order to maintain an adequate protective beach width until sufficient material had been supplied to the adjacent shore line immediately to the north of the Coast Guard tower and south of 13th Street and to the offshore zones between these points. In the beach erosion study leading to recommendation of the beach fill plan it was reasoned that maintenance by beach fill without extension of groins would be more economical, if the annual replenishment requirement would not exceed about 100,000 cubic yards. The average rate of loss of material since the beach fill was placed has been substantially in excess of this amount, and until more favorable alignment of adjacent shore lines is established, annual maintenance for the critical portion of the study area by fill alone would undoubtedly be costly.

The significant fact indicated by the surveys covering the period August 1952 to March 1955 is that about 95 percent of the fill material placed in the beach zone between Atlantic Boulevard and 13th Street was transported out of this area. The data from the periodic surveys are fairly conclusive that this fill material was ultimately deposited in

the beach zone to the north and south of the fill limits; therefore the fill material, although only partially effective in the area where it was initially placed, substantially benefited adjacent shore segments.

In its 1952 report, the Beach Erosion Board concluded that the cause of cycles of erosion and accretion on the ocean and inlet shores of Ocean City is the irregularity of supply associated with transfer of material across Great Egg Inlet, and that resumption of an adequate supply by natural processes could not be foreseen. The survey data indicate that a tremendous volume of material is moved in the offshore zones, particularly in and near the Great Egg Inlet tidal channels. Comparative bottom profiles of 1949 and 1955 off Park Place (between 3rd and 5th Streets), show that in 20 to 25-foot depths an offshore channel about 500 feet in width moved some 1,200 feet shoreward. Concurrently, between 1949 and 1955, the main gorge of Great Egg Inlet off Wesley Avenue deepened by about 20 feet and moved some 300 feet towards Longport. The volume of material involved in these offshore hydrographic changes is apparently several times larger than the volume of material artificially placed on the beach in 1952. There is little doubt but what these offshore changes tend to obscure the effects of ordinary littoral processes in the problem area, which adds to the complexity of the problem of maintaining the shore at an advanced position, regardless of the quality of sand fill utilized, either with or without groin extensions. It appears that although a large supply of material is potentially available to the problem shore by natural processes, the forces of waves and currents either do not move it to the problem area or prevent it from accumulating in the area. Presumably the present advanced position of this shore relative to adjacent shores is an influential factor causing these conditions.

#### CONCLUSIONS

Study of the behavior of the beach fill at Ocean City indicates that the rate of loss of the beach fill has exceeded the estimated rate because of the following conditions:

- a. The fineness of the beach fill material placed relative to the sand native to the beach of the problem shore,
- b. The extensive movement of material associated with shifting of the inlet channels and bars, within and adjacent to the primary problem area; and
- c. The advanced position of the problem shore line relative to the adjacent shore line to the southwest.

It is further concluded that:

- a. Although the loss of sand fill from the primary problem area was rapid, the material so lost has benefited adjacent shores.

b. The rate of loss of any beach fill placed between Surf Road and 12th Street will be high until the adjacent shore to the southwest has built out sufficiently to provide a more stable shore alignment of the island or suitable retaining structures have been built.

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